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Birth weight and obesity risk at first grade of high school in a non-concurrent cohort of Chilean children

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Abstract

Objective: To determine the association of birth weight with obesity risk at first grade of high school in Chilean children after accounting for potential confounding factors.

Design: National non-concurrent cohort of newborns. Sociodemographic information, height, weight and anthropometric measurements at first grade of high school were analysed. Birth weight was classified as macrosomia (≥4000 g), by gestational age and by ponderal index. The relationship between birth weight and obesity at first grade of high school (BMI ≥ 95th percentile of the US Centers for Disease Control and Prevention's reference) was assessed using logistic regression models adjusted for sociodemographic information at delivery.

Setting: First grade of public high school of low and middle socio-economic status in the whole country (about 77 % of Chilean children in this age group).

Subjects: Newborns (*n* 119 070) and the same number of high-school students.

Results: A positive relationship of high ponderal index (OR = 1·86, 95 % CI 1·69, 2·03), birth weight ≥4000 g (OR = 1·66, 95 % CI 1·54, 1·78) and large for gestational age (OR = 1·69, 95 % CI 1·58, 1·81) with obesity at adolescence ($P < 0·001$) was found. Macrosomic children had a higher risk of being obese at first grade of high school after controlling for prenatal confounding variables (OR = 1·63, 95 % CI 1·52, 1·76; $P < 0·001$).

Conclusions: A direct relationship between high birth weight and obesity at first grade of high school was observed in this group of Chilean children. The results highlight the significance of birth weight as a simple tool to be used as an indicator of obesity risk for children by health-care providers.

Keywords
Children
Birth weight
Obesity
Non-concurrent cohort
Chile

Throughout the world, overweight and obesity has become an epidemic. Changes in physical activity as well as eating practices are occurring in developed and developing countries affecting children and adolescents. In industrialized and developing countries, obesity has increased at a fast rate especially since the 1980s in all age groups[1–7].

In Chile the same tendency is observed, with an elevated and increasing prevalence of obesity affecting 9·1 % of children aged 2–3 years, increasing to 23 % at the time they start elementary school and reaching 25 % in adulthood[8–10]. Overall, overweight affects over half of the country's adult population, associated with a high prevalence of metabolic diseases[10,11].

Many biological and genetic factors in interaction with environmental and socio-economic conditions have been associated with obesity from early life to adulthood[12–14]. In 1989, Barker exposed the relationship between birth weight and the lifetime risk for CHD. He showed that the lower the weight of the newborn and during infancy, the higher the risk for CHD in later life, a fact that has been demonstrated in many subsequent studies[15–17]. The relationship between birth weight and later obesity has been less studied and there is insufficient evidence. However, available studies suggest rather that high birth weight and rapid weight gain at an early age are favourable conditions to develop obesity in the future[18–22]. In a Danish population-based cohort study of 252 961 newborns, Rugholm *et al.* showed that the risk of overweight increased consistently with each increase in birth weight category for children aged 6 to 13 years[21].

The purpose of the present study was to determinate the association between birth weight and the risk of adolescent obesity in a non-concurrent cohort of newborns after accounting for potential prenatal confounding factors. The study tested the hypothesis that macrosomia (birth weight ≥4000 g or >8·8 lb) or large for gestational age would increase the risk of obesity at first grade of high school.

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Materials and methods

Data from a national non-concurrent cohort of newborns and subsequent measurements at first grade of elementary- and high-school education were analysed. The cohort included 119 070 children attending public schools of low and middle socio-economic status, which represents about 77 % of Chilean children within this age group. Anthropometric measurements and sociodemographic information were obtained at birth from the national birth registry and at first grade of elementary- and high-school education from the database of the nationwide nutritional assistance programme (JUNAEB, Junta Nacional de Auxilio Escolar y Becas).

Principal variables collected for the newborn were birth weight, height, family residency (urban or rural) and mother's age, marital status and school attainment.

Weight, height, age and sociodemographic data were collected at each school by school personnel and submitted to the JUNAEB on an annual basis. To link the birth registry and the JUNAEB database, the universal national unique identifier – which is routinely included in data collection forms – was used; 93 % of identification correspondence was observed and therefore these children were included in the analysis.

Where observed information on weight and height did not have biological correspondence, they were considered 'outliers'. Because it was not possible to check the quality of the information, those values considered aberrant were eliminated: height-for-age *Z*-score <-4 or >4 and BMI-for-age *Z*-score <-4 or $>+5$. The group remaining in the study constituted 99·3 % of the newborn children and 93·2 % of the students. A comparative analysis between the data of those integrated into the cohort and the outliers did not show statistically significant differences for other variables of interest.

Birth weight was classified as: low (<2500 g); insufficient (2500–2999 g); normal (3000–3999 g); and macrosomic (≥4000 g).

Birth weight-for-gestational age was classified as: small (<10th percentile); adequate (10th to 90th percentile); and large (>90th percentile) following the Chilean national birth weight reference[23]. Also weight was classified by the ponderal index, calculated as {[birth weight (g)]/length (cm)]^3} × 100, and categorized as follows: low (≤2·49); normal (2·50–3·16); and high (≥3·17)[24]. Gestational age was classified as: pre-term (<37 weeks' gestation, under 259 d); full-term (37–41 weeks' gestation, 259–293 d); and post-term (≥42 weeks' gestation, 294 d or more).

BMI was calculated and classified in relation to the US Centers for Disease Control and Prevention's tables for age and gender[25] as: underweight (<5th percentile); normal (5th to <85th percentile); overweight (85th to <95th percentile); and obese (≥95th percentile).

For continuous variables, means and standard deviations were examined and tests of hypothesis for group comparisons were carried out. Frequency distributions were evaluated for categorical variables and the χ^2 test was used to analyse group differences. The relationship between birth weight and BMI at first grade of high school was assessed using logistic regression models adjusted for gender, age and mother's school attainment at delivery.

Results

At the time of delivery the mean age of mothers was 26 (SD 6) years, almost two-thirds were married, 40 % had completed elementary school (sixth grade) and nearly 60 % had high school or more (data not shown).

The study sample included 57 254 males and 61 816 females, with mean age at first grade of high school of 14·2 (SD 0·3) years. The anthropometric characteristics at birth and first grade of high school were within normal ranges, but with mean BMI about 2 kg/m^2 above the median of the reference value in both sexes. At first grade of high school, 25·4 % of the children were overweight or obese and a low prevalence of underweight (3·7 %) was observed (Table 1).

A positive direct relationship between birth weight and obesity at first grade of high school was observed (Table 2), with a prevalence of obesity of 5·0 % in children with low birth weight (<2500 g) and double the prevalence, 10·7 %, in those with macrosomia (birth weight ≥4000 g). The same trend was observed among those with a high ponderal index and being large for gestational age, with a doubling of obesity prevalence in relation to low ponderal index or small for gestational age at birth. In addition, the prevalence of underweight was higher among those children with low ponderal index or who were small for gestational age ($P<0·001$ for all).

A positive relationship between birth weight and obesity at first grade of high school was found through logistic regression models, as seen in Table 3. Among newborns with a high ponderal index, the risk of obesity was almost 90 % higher (OR = 1·86, 95 % CI 1·69, 2·03; $P<0·001$) compared with those having a low ponderal index; and the same tendency was also observed for those in the large for gestational age category *v.* small for gestational age, with 69 % more risk of being obese at first grade (OR = 1·69, 1·58, 1·81; $P<0·001$). An inverse relationship between low birth weight and obesity at later age, using different classifications of birth weight, was observed (data not shown). As expected, obesity in the first grade of elementary school was the principal factor predicting obesity in the first grade of high school, by which it was excluded from the multivariate model. The logistic regression model adjusted for prenatal variables showed an increased risk for obesity in first grade of high school in macrosomic newborns and in males (OR = 1·63, 95 % CI 1·52, 1·76 and OR = 1·09, 95 % CI 1·04, 1·14, respectively; both $P<0·001$).

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Table 1 Anthropometric characteristics of newborns and children in first grade of high school by sex, Chile (*n* 119 070)

	Males		Females		Total		
	Mean	SD	Mean	SD	Mean	SD	*P**
Newborns							
Birth weight (g)	3367	495	3258	468	3306	489	<0·001
Height (cm)	49·9	2·2	49·2	2·2	49·5	2·2	<0·001
Gestational age (weeks)	39·1	1·5	39·0	1·5	39·1	1·5	<0·01
Ponderal index	2·70	0·28	2·73	0·29	2·71	0·32	<0·001
First grade of high school							
Age (years)	14·2	0·3	14·2	0·3	14·2	0·3	NS
Weight (kg)	56·8	11·0	54·3	9·4	55·5	10·0	<0·001
Height (cm)	163·7	7·8	157·7	6·1	160·0	7·6	<0·001
BMI (kg/m^2)	21·1	3·3	21·8	3·5	21·5	3·4	<0·001
	%		%		%		
Nutritional status							
Underweight	4·7		2·7		3·7		
Normal weight	69·9		71·8		70·9		
Overweight	18·0		18·8		18·4		
Obese	7·4		6·7		7·0		<0·001

*$\chi^2 = 370{\cdot}6$, $P < 0{\cdot}001$.

Table 2 Nutritional characteristics of newborns and subsequent BMI classification at first grade of high school, Chile (*n* 119 070)

	Underweight (%)	Normal weight (%)	Overweight (%)	Obese (%)	*P*
Birth weight					
Low	5·6	73·2	16·3	5·0	
Insufficient/normal	3·7	71·3	18·2	6·8	
Macrosomia	2·1	65·7	21·5	10·7	<0·001
Ponderal index					
Low	5·2	73·9	15·2	5·7	
Normal	3·4	70·7	18·9	7·1	
High	2·0	62·7	23·3	12·0	<0·001
Birth weight-for-gestational age					
Small	5·1	73·8	15·7	5·4	
Adequate	3·5	71·1	18·5	6·9	
Large	2·4	64·7	22·1	10·9	<0·001

Table 3 Odds ratios and 95 % confidence intervals, unadjusted and gender-adjusted, of the association between birth weight and sociodemographic variables with obesity at first grade of high school, Chile (*n* 119 070)

	Crude logistic regression model		Adjusted logistic regression model	
Explanatory variable	OR	95 % CI	OR	95 % CI
Macrosomia	1·66	1·54, 1·78	1·63***	1·52, 1·76
High ponderal index	1·86	1·69, 2·03		
Large for gestational age	1·69	1·58, 1·81		
Male	1·10	1·07, 1·13	1·09***	1·04, 1·14
Teen mother	0·91	0·84, 0·98		
Mother's education <6 years	1·10	1·03, 1·18		
Obesity at first grade of elementary school	6·87	6·56, 7·20		

***$P < 0{\cdot}001$.

Discussion

The study findings showed a positive relationship between children's birth weight indicators (high ponderal index, macrosomia, large for gestational age) and obesity at first grade of high school, after controlling for the effects of confounding prenatal variables. Regarding attributable risk, it can be concluded that about one-third of obesity in children at first grade of high school could be prevented with early interventions in the macrosomic newborn. High birth weight by itself is an important obesity risk indicator that can help health-care providers

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prevent obesity at early stages of childhood development, and therefore prevent chronic diseases in adulthood.

The results validate the direct and statistically significant relationship between high birth weight and obesity in Chilean elementary-school children demonstrated in previous studies, which found even higher odds ratios relating macrosomia and obesity in children at 7 years of age[19,26].

Gestation and early infancy is one of the three critical periods for the development of obesity which would persist throughout childhood and adolescence. Different studies have documented the relationship between high birth weight and increased risk of obesity starting at childhood. A systematic review on the association of birth weight or rapid growth indicated that height and weight, as well as rapid growth, increase the likelihood to become obese[20,21,27].

In contrast, low birth weight has been suggested as a protective factor for overweight and obesity among German children and it can contribute to program lean body mass later in life[28,29]. These findings suggest that children who were under unfavourable nutritional conditions during gestation and at birth may still present those conditions at the time they reach school age.

Maternal obesity before conception or during gestation has a strong association with fetal macrosomia and also with the risk of the child developing obesity after birth[30,31]. This association can be explained by genetic factors, fetal programming or environmental conditions which continue affecting the child after birth. The current study cannot determine the strength of these factors, but is very likely that parents' lifestyles can strongly affect their children's nutritional status. Similarly, among Chilean children, a family history of obesity, being breast-fed for less than 4 months and high birth weight-for-gestational age have been identified as risk factors for obesity in childhood[32].

At first grade of high school the anthropometric characteristics of the cohort were within the normal values, although the mean BMI was about two units higher (21·5 *v.* 19·4 kg/m^2) and weight almost 10 % above the expected value for their age range. In addition, weight gain between birth and the first grade of high school was higher than the expected normal gain (52·2 *v.* 47·6 kg), with a normal height increase within the same period, which explains the higher BMI.

As described above in 'Materials and methods' the response variable was dichotomous, with obesity compared against the rest (underweight, normal weight or overweight), using binary logistic modelling as the analytical strategy. In considering overweight as a separate category in a polytomous model, the same trends were obtained, so such results are not shown in the analyses.

The results highlight a significant decline in the prevalence of obesity between 7 and 14 years, despite the increase in weight at that stage still being above the reference range. This could be explained by the greater dispersion of the normal range for adolescence, as the cut-off point for obesity accounts for 20 % of the median BMI at age 7 years and about 40 % at age 14 years.

The study results can provide valuable information that can assist and guide the formulation of public health policy that aims to protect the health of vulnerable groups from birth to early age and throughout the school age by preventing obesity and its consequential health problems. Policies that provide guidelines as well as the implementation of greater levels of physical activity and the provision of healthy meals in schools are needed.

Some study limitations related to the survey methods or data collection, as well as the data analyses, should be considered. A typical limitation related to analyses of non-concurrent cohorts concerns to the nature of the data; i.e. they are secondary or already collected data, and therefore the researcher is unable to go back to the study subjects, as well as to review collected data, or correct or impute inaccurate or missing values. Additionally, data on variables clearly associated with overweight such as maternal nutrition, child eating and physical activity practices, Tanner stage and body fat composition were not available in the present non-concurrent cohort. Another weakness comes from the fact that the children in the present study were representative of just part of the Chilean school population (lower socio-economic level), and cannot be extrapolated nationally. Nevertheless, the study has strengths such as the large study sample and the high level of participation at baseline and follow-up.

We conclude that birth weight constitutes a good indicator of risk of obesity from birth. In future studies it would be suitable to explore the causal factors of this association that can be linked by genetic environmental factors and/or fetal programming.

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